arXiv:0811.0653v1 [physics.flu-dyn] 5 Nov 2008

Visualization of flow over a golf ball at Re = 110,000.

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November 5, 2008

Abstract

The drag on a golf ball can be reduced by dimpling the surface. There have been few studies, primarily experimental, that provide quantitative information on the details of the drag reduction mechanisms. To illuminate the underlying mechanisms, Direct Numerical Simulation (DNS) is applied to the flow around a golf ball using an immersed boundary method. Computations are performed using up to 500 processors on a range of mesh resolutions from 61 million points to 1.2 billion points. Results are presented from simulations performed at a Reynolds number of Re = 1.1×10^5 using a grid of 1.2 billion points. This video shows the development of instabilities in the near-surface flow, as well as the delay of complete separation due to the development of local shear layers that lead to local separation and reattachment within individual dimples.

1 Introduction

This fluid dynamics video shows the evolution of the flow over a golf ball from different several perspectives in space. The variables shown in the video are isosurfaces of the Q-criterion [1] colored by spanwise vorticity, contours of spanwise vorticity, and an isosurface of the vorticity magnitude.

The first section of the video presents an isosurface of the Q-criterion colored by the spanwise vorticity, where white and blue represent positive

and negative values of the spanwise vorticity. As the view moves closer to the golf ball, several "trains" of vortices become apparent near the surface about 45 degrees from the stagnation point on the front of the ball. These vortices are related to the geometry of the surface as the generation of the structures follows the lines of the dimples in the streamwise direction.

The Q-criterion isosurface is faded out to reveal planar contours of the spanwise (out-of-plane) vorticity. As the flow evolves from the front to the rear of the dimples, local detachment leads to flow structures generated by the developing shear layer. The different contour planes shown suggest the local detachment region within individual dimples varies with the streamwise direction.

The contours of the spanwise vorticity are faded out and replaced by a transparent isosurface of the vorticity magnitude. Here, the vortical structures in the flow are demonstrated to have streamwise and spanwise dependence, and the effect of the dimples is apparent in the generation of vortices in individual dimples. As the observer moves away from the golf ball, the effect of the local vortex generation by the dimples is evident in the near-wake region.

The video animation file can be found at golfball_movie_cropped720x480_qmax500k.mpg

2 References

Hunt, J., Wray, A., Moin, P., "Eddies, stream, and convergence zones in turbulent flows", *Center for Turbulence Research Report*, CTRS88, 1988.